

THE EFFECTS OF CARBON DIOXIDE ON METHYL BROMIDE TOXICITY

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The effects of carbon dioxide on the toxicity of methyl bromide to stored product insects have been studied for more than 60 years. Synergistic effects have been attributed to the fact that carbon dioxide acts directly on the insect's spiracle muscle to cause immediate opening. As little as 2-3% of the gas causes the spiracle to remain open resulting in continuous respiration thereby increasing the effective dose of the fumigant. Also, sustained opening of the spiracle can cause uncontrolled water loss leading to dehydration.

Based on the fact that carbon dioxide can increase the toxicity of fumigants like methyl bromide, many studies have been done to determine if carbon dioxide mixtures can either shorten the exposure period of methyl bromide fumigations or reduce methyl bromide's effective dose. However, results are mixed. Some studies show no effect on toxicity while others show synergism. Some show that as little as 5% carbon dioxide causes increased toxicity while others show as much as 30-40% is required to effectively reduce methyl bromide doses. In addition, none of the studies are comprehensive and include only a few insect species and a limited number of life stages.

Using modified desiccators as fumitoria, we tested the relative toxicity of carbon dioxide-methyl bromide mixtures to all life stages of four species of insects that are common pests of dried fruits and nuts: confused flour beetle, *Tribolium confusum* duVal; red flour beetle, *Tribolium castaneum* (Herbst); warehouse beetle, *Trogoderma variabile* (Ballion); and sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.). Results of the laboratory tests at 27°C and 70% RH showed that the effects of 5, 10, 15, and 20% carbon dioxide are varied depending on the pest species and also on the life stage. Within each species, the egg stage was the most susceptible to the fumigant mixtures and larvae and pupae were the most tolerant. Although the two flour beetle species were about equally tolerant to methyl bromide alone, the confused flour beetle responded to carbon dioxide mixtures much more than did red flour beetle. Carbon dioxide antagonized the toxicity of methyl bromide to eggs of warehouse beetle but synergized its toxicity to all other life stages of all species. Generally, the higher the concentration of carbon dioxide in the mixture, the greater the synergism. In some cases however, 20% carbon dioxide was not significantly more synergistic than the 15% concentration or the 10% concentration. There was no single carbon dioxide concentration that equally synergized its toxicity to all life stages of the four pest species. Results of these tests show that carbon dioxide can effectively reduce methyl bromide doses and/or shorten its exposure time. However, efficacy of pest control technologies utilizing carbon dioxide-methyl bromide mixtures depends upon the particular pest species and life stages present.